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Indian Standard

METHOD FOR TEMPERATURE MEASUREMENT OF PETROLEUM AND ITS PRODUCTS

PART 2 ABOVE ATMOSPHERIC PRESSURE

(First Revision)

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Indian Standard

METHOD FOR TEMPERATURE MEASUREMENT OF PETROLEUM AND ITS PRODUCTS

PART 2 ABOVE ATMOSPHERIC PRESSURE

(First Revision)

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Indian Standard

METHOD FOR TEMPERATURE MEASUREMENT OF PETROLEUM AND ITS PRODUCTS

PART 2 ABOVE ATMOSPHERIC PRESSURE

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part 2) (First Revision) was adopted by the Indian Standards Institution on 14 November 1983, after the draft finalized by the Petroleum Measurements Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

0.2 This standard was first issued in 1964. In the present revision, the standard has been reviewed and revised in the light of recent advances in the field of petroleum measurements. In this revision, the use of gas-filled instruments has been restricted due to the possible inaccuracies which result in their use because of the pressure head in the capillary. Further, the use of thermal-sensitive resistors (thermistors) have been recommended and safety precautions for pressure and vapour-tight tanks have been included.

0.3 The correct determination of temperature is essential in all measurements of oil in bulk storage since errors may seriously affect the accuracy of calculated quantities. The need for care in all measurements cannot, therefore, be over-emphasized. In all calculations concerning the measurement of oil in bulk, the mean temperature of the oil in each container is required; and the object of this standard is to lay down methods which will enable accurate determination of this temperature.

0.4 This standard (Part 2) covers method for measurement of temperature of materials at pressure above atmospheric (*see* **1.1**). Part 1 of this standard covers methods for determining temperature of petroleum and its liquid products when in bulk and at atmospheric pressure.

0.5 Taking into consideration the views of producers, distributors and consumers, the Sectional Committee responsible for the preparation of this standard felt that it should be related to the trade practices followed in the country in this field. Furthermore, due weightage had to be given to the need for international co-ordination among standards prevailing in different countries of the world in this field. These considerations led the Sectional Committee to base this standard on the standards and other publications issued by the Institute of Petroleum (IP), London; American Society for Testing and Materials (ASTM), Philadelphia, USA, and International Organization for Standardization (ISO).

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 2) prescribes the method for determining temperatures of petroleum and its products when such products are stored in liquid state in bulk at pressure above atmospheric. Tanks and vessels which communicate with outside atmosphere during sampling or gauging, but which otherwise operate at pressures few centimetres of water above atmospheric are excluded from the purview of this standard.

1.1.1 Vertical and horizontal cylinders, hemispheroids, spheroids, and spheres are some of the major types of pressure storage vessels. The usual pressure range is 0·175 to 0·35 kg/cm^2 for plain and noded hemispheroids, 0·175 to 1·0 kg/cm^2 for noded spheroids, 0·35 to 2·0 kg/cm^2 for plain spheroids, 2·0 to 15·0 kg/cm^2 for spheres and 1·0 to 21·0 kg/cm^2 for cylindrical drums.

2. OUTLINE OF THE METHOD

2.1 Determination of the temperature of liquids in pressure storage presents peculiar difficulties, especially in the cases of liquefied petroleum gases which vaporize under normal atmospheric conditions. The sampling can, and conventional thermometers described in IS : 1519 (Part 1)-1983† cannot be used for temperature measurement of liquids in pressure vessels. In these cases, temperatures are determined by means of thermowells extending into the bulk of the liquid, in conjunction with either the industrial-type angle-stem thermometers, pressure-actuated thermometers, resistance thermometers or thermo-electric pyrometers, or in certain cases by means of a gas-lock equipment permanently fitted to the pressure vessel described in **4.1** to **4.9**.

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*Rules for rounding off numerical values (*revised*).

†Method for temperature measurement for petroleum and its products, Part 1 (*first revision*).

For tanks equipped with gas-lock arrangements, temperatures are taken by lowering the thermometer assembly through the pressure lock to the specified tank level. After the thermometer assembly has attained the temperature of the product, it is quickly withdrawn and the temperatures reading recorded. For tanks equipped with thermowells, temperatures are taken by reading thermometers placed in the thermowells at the specified tank levels. Average temperature of the product is then calculated and reported.

3. SAFETY PRECAUTIONS FOR PRESSURE AND VAPOUR-TIGHT TANKS

3.1 The general precautions listed under **2** in IS : 1519 (Part 1)-1983* shall be observed.

3.2 The following additional precautions shall also be observed :

a) All gauging equipment used on pressure-type tanks shall be designed to withstand a pressure equal to the working pressure plus an adequate safety factor.

b) Gas-lock apparatus is available for various ranges of operating pressures. In no circumstances shall this apparatus be used on tanks where higher pressures than that for which it was designed make its use hazardous.

4. APPARATUS

4.1 Thermowells for Cylindrical Vessels — In any container, there shall be at least one thermowell at level approximately 0·5 metre above the lower capacity mark (the lower capacity mark shall be determined in relation to the centre line of the regular draw-off nozzle). Another thermowell may be located 0·5 metre below the upper capacity mark provided the distance between the lower and the upper thermowells exceeds one metre (the upper capacity-mark is generally determined in relation to expansion characteristic of the liquid stored). Additional thermowells may be spaced equally at intermediate levels with spacing between successive levels not exceeding 2 metres.

4.1.1 Thermowells installed in the sides of a container shall extend into the container for a distance of at least one metre to avoid local thermal effects at the wall. With smaller diameter vessels (say vessels having diameter 2 metres and less) thermowells installed through the sides or top at the desired level shall extend up to the centre line of the vessel.

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*Method for temperature measurement for petroleum and its products, Part 1 (*first revision*).

4.2 Thermowells for Horizontal Cylindrical Vessels — Thermowells may be installed through the top tangent line to extend to the desired level. When this is done, in case of large vessels, thermowells will be generally away from the vessel wall by the desired margin of one metre except perhaps the uppermost and lowermost thermowells.

4.3 Thermowells for Spheres and Spheroids — In spheres and spheroids, good results may be obtained with pressure actuated or resistance thermometers in long thermowells installed vertically from the top of the vessel and extending downward to the desired level. In such vessels, one thermowell shall be located above the lower capacity mark, another below the upper capacity mark and additional thermowells at intermediate levels in accordance with the requirements given in **4.1**.

4.4 All thermowells shall have square or hexagonal heads, and shall be threaded to screw into collars welded into the tank or pipeline so that they can be removed for inspection when required. A light packing of some suitable material shall always be inserted in the opening of each thermowell around the stem of the thermometer to prevent atmospheric conditions affecting the bulb.

4.5 Gas Lock and Sampler

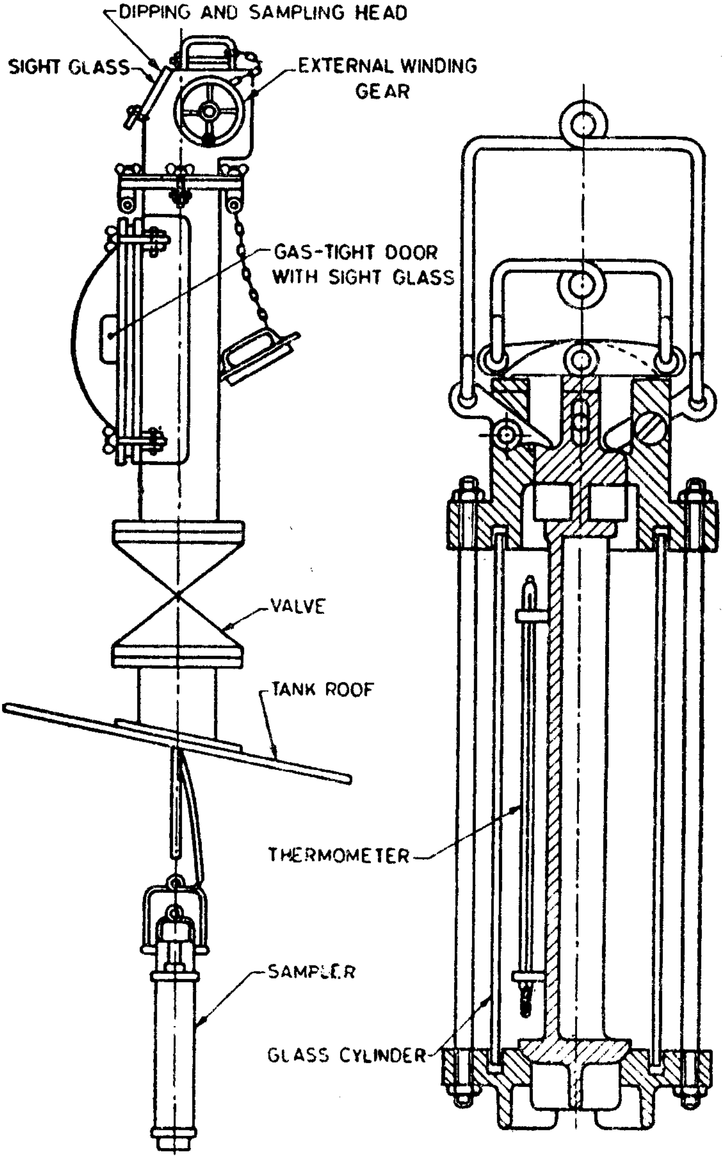
4.5.1 *Gas-Lock* — The gas-lock (Fig. 1) consists of the following three main parts :

a) A valve which is bolted to the tank roof,

b) A length of pipe, forming the body of the apparatus, which is bolted to the valve. This body is fitted with a gas-tight door closed with pressure clips. The door may be fitted with a sight glass, and

c) The dipping and sampling head, which is bolted to the top of the body and consists of a gas-tight housing for an externally operated winding-gear for the measuring tape. The head is fitted with a sight glass for viewing the tape and with a plunger for applying ullage paste to the tape. A second winding-gear may also be fitted for taking a second ungraduated tape for operating the special flushing-type sampler which may be used in conjunction with the apparatus. The precise design of the equipment varies according to the manufacturer, but the apparatus shall possess an adequate margin of strength for the pressure under which it is to be used.

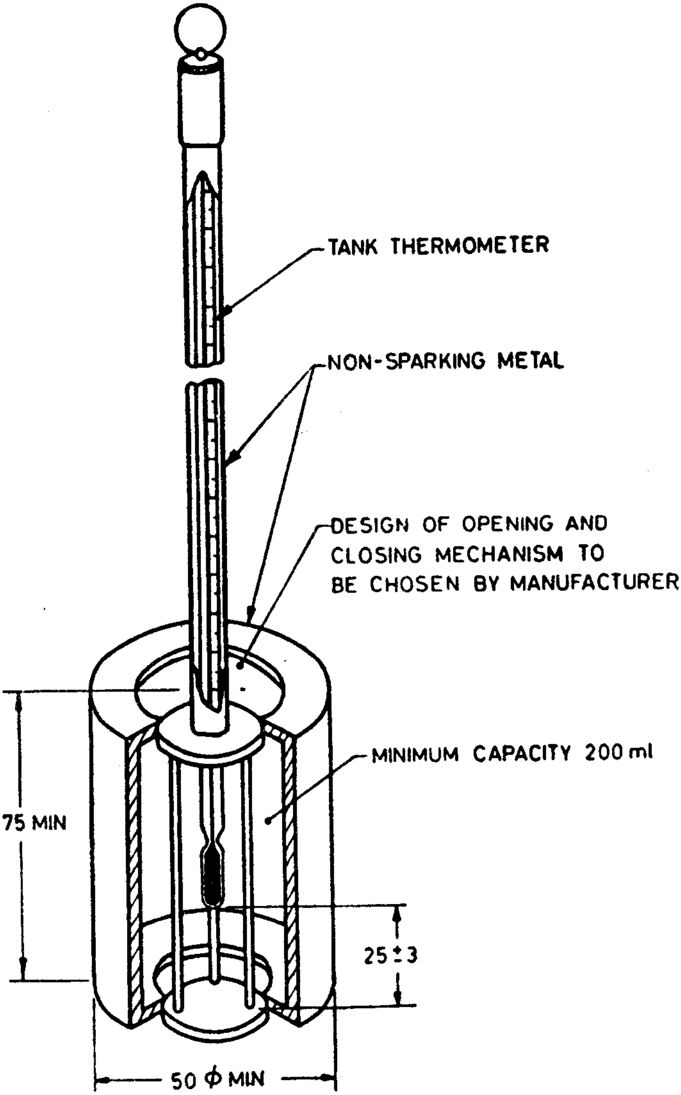
4.5.2 *Maintenance* — The gas lock shall be inspected at frequent intervals and shall be adequately maintained. Particular care shall be taken to see that gaskets fitted to the dipping head and to the gas-tight door are kept in good condition.



SPECIAL SAMPLER FOR USE WITH GAS-LOCK APPARATUS

FIG. 1 GAS-LOCK APPARATUS

4.5.3 *Sampler* — An ordinary flushing type case thermometer assembly shown in Fig. 2 or alternately the special type flushing sampler shown in Fig. 1 may be used with the gas-lock.



All dimensions in millimetres.

FIG. 2 FLUSHING TYPE CASE THERMOMETER ASSEMBLY

4.5.3.1 The ordinary flushing type case (*see* Fig. 2) consists of a cylindrical chamber of at least 200 ml capacity, and an armour, or a protecting tube for the thermometer, rigidly attached to the chamber. The case and tube shall be made of non-sparking material. The thermometer shall be attached to the case so that the bottom of the bulb shall be approximately 25 ± 3 mm above the bottom of the case. The chamber shall have quick-acting closures at top and bottom which, in the open position, will assure a free path for liquid flow through the chamber and across the thermometer bulb. In the closed position, the closures shall assure the retention of a full chamber of liquid. The apparatus shall be so designed that the closures can be operated by a jerk of the suspension chain or cord, or by some other suitable remote control. The device shall be of such a material and construction that not more than the specified flushing time will be required for the determination of the temperature of any petroleum oil.

4.5.3.2 The special type flushing sampler (*see* Fig. 1) consists of a glass body having a capacity of about one litre and closed top and bottom with a valve assembly held in place with draw bolts. The valves are operated by two sets of levers which are actuated by taking the weight of the sampler on them. The interior of the glass body is fitted with clips for holding a liquid-in-glass thermometer.

4.6 Industrial Type of Thermometer (Angle-Stem) — These are of the liquid-in-glass type having the bulb and a portion of the stem enclosed in a metal sheath which fits closely into a thermowell (*see* **4.1** to **4.4**). The scale portion of the stem may be at an angle to the rest of the stem and is usually reinforced by a metal plate. The scale may be engraved either on the metal plate or on the stem as desired, the latter being preferable; but when a metal scale is employed the glass stem of the thermometer shall also be etched with at least two well-spaced reference lines or pointing marks corresponding to similar lines engraved on the metal scale. Angle-stem thermometers are calibrated for partial immersion corresponding to the effective length of the bulb and tail contained in the thermowell.

NOTE — Due to thermal capacity and conductivity of the metal parts the industrial type angle-stem thermometers may give inaccurate reading when the atmospheric temperature differs greatly from that of the contents of the container, but when great difference do not occur their use is permissible.

4.6.1 A typical assembly is shown in Fig. 3. When angle-stem thermometers are used for measuring temperatures in tanks, the tail shall be of such length that when the thermometer is mounted in its pocket the bulb chamber shall be not less than 450 mm and preferably not less than 750 to 900 mm from the tank shell. When used for the measurement of temperatures of oil flowing in pipelines the tail shall be of such length that the bulb chamber is not less than 100 mm from the pipe wall, but preferably the thermometer should be mounted so that an immersion length of at least 450 mm can be accommodated.

4.6.2 The recommended ranges, general requirements and special requirements as given under **3.3** and Appendix A of IS : 1519 (Part 1)-1983* shall apply to these types of thermometers also.

4.6.3 The thermometer pocket used with angle-stem thermometers shall normally be supplied as an integral part of the assembly. The pocket shall be made of stainless steel of minimum wall thickness to provide adequate mechanical strength and rapid response time, which should in any case not exceed one minute. The internal length shall be such as to accommodate the tail of the thermometer and the machined bore shall have such a diameter as to provide a piston fit for the bulb.

4.7 Pressure-Actuated Thermometers — In these instruments the thermal expansion of a liquid, vapour, or gas (or a combination of these) is employed to actuate a calibrated mechanism operating a pointer moving over a dial or a pen arm on a revolving chart, according to whether an indicating or recording instrument is required. There are many reliable types and makes in the market, but they all consist of the following fundamental parts :

a) A sensitive pressure bulb containing the actuating medium, which is installed in a thermowell immersed in the material whose temperature is required.

b) A capillary tube filled with actuating medium connecting the bulb to the sensing element.

c) A case containing a sensitive diaphragm or Bourdon tube responding to changes of pressure set up in the bulb and capillary by changes of temperature, and a mechanical linkage multiplying the movement of the diaphragm or tube and transferring this motion to a pointer or pen arm. In the latter case, a further mechanism to hold a chart and revolve it at a fixed speed is added.

The three main types of pressure actuated thermometers are covered in **4.7.1** to **4.7.3**.

4.7.1 *Gas-filled Instruments* — In this type of instrument a suitable gas is used as the actuating medium. The basic principle of the instrument is that if the volume of a given mass of gas is kept constant, the absolute pressure will vary directly with the absolute temperature of the gas. A compensating device shall be fitted to deal with ambient temperature variations. The gas occupying the space inside the bulb, capillary, and mechanism is of very low density and even though there may be a difference in level between the bulb and the indicating mechanism, there will be no measurable inaccuracy in the temperature due to pressure

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*Method for temperature measurement of petroleum and its products: Part 1 (*first revision*).

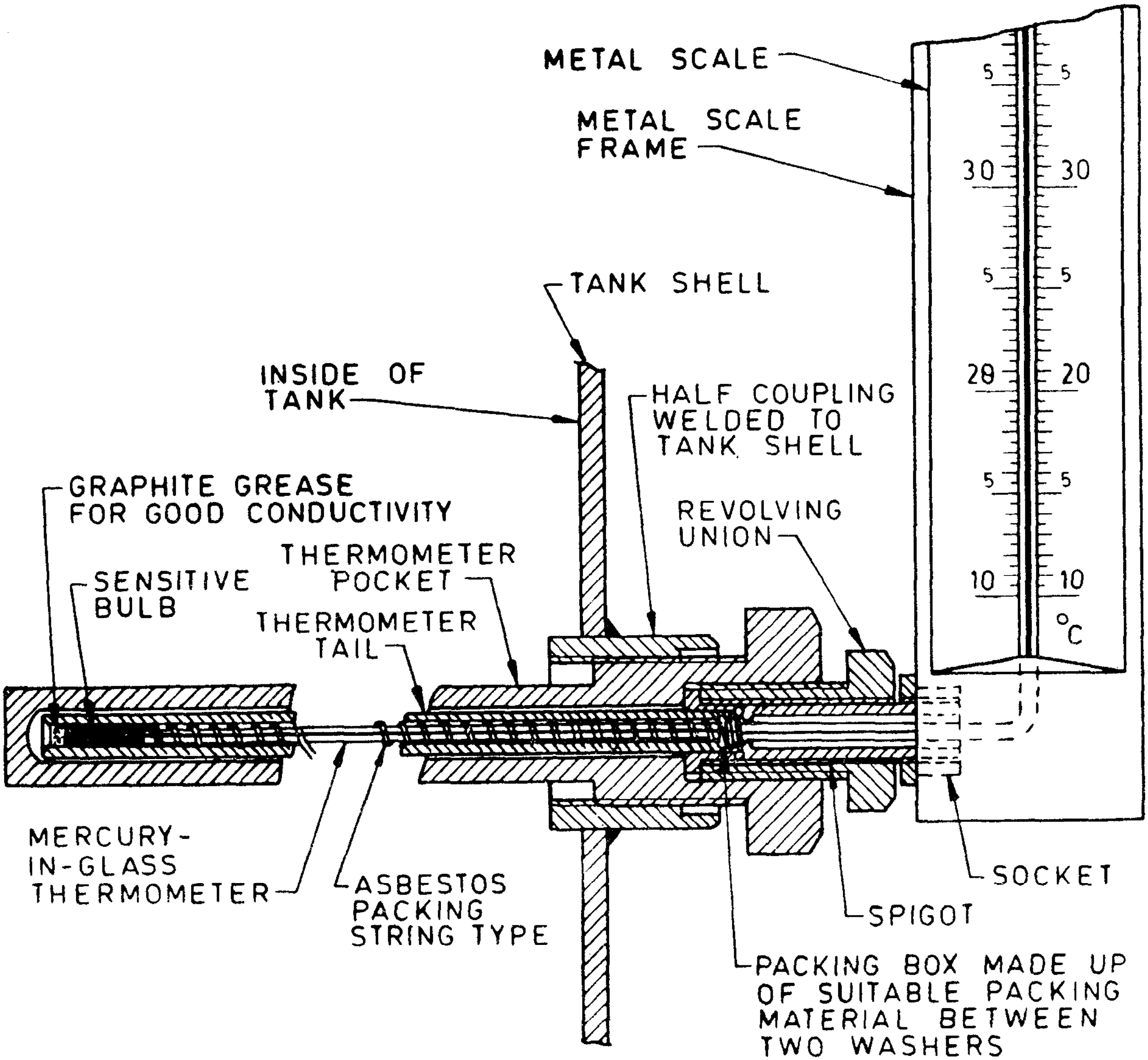
METAL SCALE
METAL SCALE FRAME
TANK SHELL
INSIDE OF TANK
HALF COUPLING WELDED TO TANK SHELL
GRAPHITE GREASE FOR GOOD CONDUCTIVITY
REVOLVING UNION
THERMOMETER POCKET
SENSITIVE BULB
THERMOMETER TAIL
MERCURY-IN-GLASS THERMOMETER
ASBESTOS PACKING STRING TYPE
SOCKET
SPIGOT
PACKING BOX MADE UP OF SUITABLE PACKING MATERIAL BETWEEN TWO WASHERS
5
5
30
30
5
5
20
20
5
5
10
10
°C

Fig. 3 Typical Angle-Stem Thermometer Assembly

As in the Original Standard, this Page is Intentionally Left Blank head in the capillary. However, the instrument requires calibration for altitude (barometric pressure), and capillary error may be, therefore, difficult to eliminate. As the accuracy is not better than 1 percent full-scale deflection, the instrument is not generally recommended for bulk oil measurement purposes.

4.7.2 *Vapour-Pressure Instruments*

4.7.2.1 Liquids in contact with their vapours exert a pressure, termed the vapour pressure, which is characteristic for different liquids. The vapour pressure of a given liquid is dependent on its temperature, and this relationship is the basis on which the vapour pressure thermometer is constructed. In general the instrument is unaffected by ambient temperature near either the indicating mechanism or the capillary when the temperature being measured differs appreciably from ambient. If the bulb has been correctly filled there will always be a free surface between liquid and vapour in the bulb, and the instrument will show the temperature surrounding the bulb regardless of the ambient temperature.

4.7.2.2 The vapour-pressure instrument capillary is normally filled with liquid, as ambient temperatures are usually below the boiling point of the filling liquid. If the bulb is placed above or below the recorder, this head of liquid will appreciably affect the calibration of the instrument and shall be considered in the initial calibration and in the testing of the instrument in the field.

4.7.2.3 The range of the thermometer is limited due to the fact that the maximum temperature is kept below the critical temperature of the liquid with which it is filled. The range is further limited by the non-linear nature of the scale.

4.7.2.4 The thermometer is also subject to inaccuracies when measuring temperatures fluctuating about the mean ambient temperature of the capillary and Bourdon tube obtaining at the time. A time lag results from condensation taking place in the bulb when the temperature being measured passes downwards through ambient temperature and condensation in the capillary and Bourdon tube when the temperature of the bulb rises about ambient. When this temperature transition through the ambient temperature is taking place the pointer moves in a series of 'kicks ' which may sometimes even reverse the direction of movement temperature temporarily.

4.7.2.5 Errors due to changes in atmospheric pressure may be greater with this type of instrument than with mercury-in-steel thermometers; however, these can be altered by calibration on a day-to-day basis when this becomes necessary.

NOTE — The vapour-pressure thermometer, although generally cheaper than comparable mercury-in-steel thermometers, has a number of disadvantages (*see* **4.7.2.1** to **4.7.2.5**) and this type of thermometer is not, therefore, recommended for general use for bulk oil measurement purposes.

4.7.3 *Liquid-Filled Instruments* — The liquid-filled thermometer relies on the cubical expansion of a liquid to develop the pressure used to operate the indicating or recording mechanism. The pressure varies directly with the temperature and operates over wide temperature ranges. Since the expansive force available is large, it is practicable to use a very stiff diaphragm or Bourdon tube and to fill the system with liquid under high pressure. The head due to the difference in level between the bulb and the recording instrument is then so small in comparison with the pressure inside the bulb that its effect may be neglected. Compensation shall, however, be allowed for ambient temperature changes.

4.7.3.1 Mercury is commonly used as the filling medium. Such instruments, usually known as mercury-in-steel thermometers, fitted with dial and pointer indicators, are recommended. When used they shall conform to the following specification :

a) *Indicator* — The dial indicator shall have a minimum diameter of 100 mm and shall be so engraved and fitted with a fine pointer as to provide temperature discrimination within 0·25°C. The scale shall be subdivided in units of 0·5°C. The indicator movement shall be provided with suitable compensation to allow for a change in temperature of the indicator, of 15°C. The angle of the indicator dial in relation to the longitudinal axis of the stem shall conform to the configuration of the tank to permit the ease of reading.

b) *Thermometer pocket* — The thermometer pocket, which shall have a minimum length conforming to the requirements of **4.6.3**, shall be provided by the thermometer manufacturer with its companion thermometer assembly. It shall be made of non-corrodible metal of minimum wall thickness, having an inside diameter not more than 0·4 mm greater than the outside diameter of the bulb to provide a response time of not more than 1 minute (*see* **4.4**).

c) *Bulb* — The bulb of the thermometer shall be of the same diameter overall allowing a piston fit in the pocket, and shall have a sensitive portion of 150 mm minimum length.

d) *Range* — The range shall be such as to cover the expected operating temperatures and to provide the necessary accuracy and discrimination. Temperature ranges of 0° to 40°C and 30° to 70°C are convenient.

e) *Accuracy* — The accuracy of measurement at any point in either range shall be within 0·25°C for the complete equipment when used within an ambient range of −10° to +50°C.

f) *Standardization and periodical checking* — Mercury-in-steel thermometers shall be standardized before being installed, and thereafter shall be checked at not less than yearly intervals using a technique similar to that outlined under **A-2.3** of IS : 1519 (Part 1)-1983*. The thermometers shall be tested when contained in their companion thermometer pocket assembly, except where for reasons of operational necessity the thermometer pocket cannot be removed from the position in which it is installed.

4.7.3.2 Remote reading mercury-in-steel thermometers may be used. Adequate precaution shall be given to the steel capillary linking the sensitive bulb to the indicator. The instrument shall be supplied with its companion pocket, in which the bulb shall fit closely. Care shall be exercised when the bulb of a remote-reading instrument is inserted or removed from its pocket in order to avoid damage to the capillary.

4.7.4 *Maintenance* — The mechanical indicating or recording device used with the pressure-actuated thermometer shall receive regular and adequate maintenance. The thermometer shall be compared periodically with a standard thermometer as outlined under **A-2.3** of IS : 1519 (Part 1)-1983* but it is recommended that the bulb shall not be removed from the thermowell for the purpose more frequently than once yearly, in view of the possibility of damage to the capillary.

4.8 Thermoelectric Thermometers

4.8.1 *Resistance Thermometer* — The resistance thermometer depends upon the consistent variation of the electrical resistance of a metallic conductor with its change in temperature. The change in resistance is measured by Wheatstone bridge circuit incorporating an indicating or recording device scaled directly in degrees Celsius. The conductor often employed is platinum or nickel since both can be highly refined and made to have very little variation in temperature coefficient from batch to batch. Nickel-wound resistance thermometer elements have a useful range of − 200° to +350°C, and platinum-wound resistance elements have a useful range of −200° to +600°C. Copper-wound resistance elements can also be used, but over a restricted range of −40° to +175°C. It is essential that any change in resistance in the system is confined to the thermometric element. This is taken care of by the circuit employed, which accurately balances out and automatically compensates for change in the electrical resistance of all other parts of the resistance thermometric circuit. The indicating or recording instrument may then be mounted sufficiently away from the location of its associated temperature sensitive element without fear of engendering inaccuracies in the instrument reading.

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*Method for temperature measurement of petroleum and its products, Part 1 (*first revision*).

For the majority of industrial applications resistance-thermometer elements and their associated components are permanently installed. If, however, spot readings are to be taken the sensitive element must be left in the thermowell for a specified time before taking a reading. Alternatively, the resistance element can be permanently installed in its thermometer pocket and with its connections terminating at a suitable socket into which the lead of a portable indicator can be plugged (*see* **4.8.4.2**).

4.8.1.1 The indicating or recording instrument associated with resistance-thermometer elements may be of the millivolt-meter type, which indicates or records by means of a pointer or pen attached to a permanent-magnet moving-coil system, swinging over the scale or chart, or the instrument may be of the self balancing potentiometric type where the mechanism therein maintains the Wheatstone bridge in a constant state of balance. The latter type is more accurate of the two, since the bridge is always in balance, consequently variations in the voltage applied to the bridge do not affect the accuracy of the reading. In the former (millivolt-meter) type the accuracy of indication depends upon the stability of the voltage supplied to the bridge. Certain millivolt-meter type resistance thermometers employ automatic bridge voltage compensating devices which keep the instrument readings accurate within specified limits in spite of relatively large variations in the supply voltage to the bridge. Alternatively, radiometer indicators may be used, as these are relatively unaffected by variations in supply voltage. Many temperature-sensitive elements can be connected to one indicating or recording instrument by the use of an appropriate type of switch, which shall ensure that the instrument is not subjected to a heavy current surge, causing the pointer to swing violently when changing from one element to another. A combined supply on-off switch and range-change switch, the former breaking the supply before the latter can be operated, is a satisfactory arrangement. The indicating instrument used shall conform to the specification given in **4.8.4.1** and **4.8.4.2**.

4.8.2 *Thermoelectric Pyrometers*

4.8.2.1 Thermoelectric pyrometers depend for operation on the fact that if wires of two dissimilar metals are joined and the junction is heated, an electric potential is set up between the 'hot' junction and the cold ends of the wires, this potential being proportional to the difference in temperature. By using a sensitive millivolt-meter or potentiometer this potential may be measured. Instruments employing a millivolt-meter are simpler in construction but potentiometric instruments have the advantage of being largely independent of variations in resistance of the external circuit. Both types may be arranged for multi-point readings and are usually permanently installed.

4.8.2.2 Since the voltage generated is proportional to the difference in temperature between the hot and cold junctions, changes in ambient temperature must be compensated. This is accomplished automatically in most instruments.

4.8.2.3 Due to the comparatively narrow range of temperature measurements normally required and the limited accuracy of thermocouple thermometers over the range, this type of thermometer should not normally be used for determining the temperature of tank contents for bulk oil measurement purposes.

4.8.3 *Thermal Sensitive Resistors (Thermistors)* — Because of the small size of the semi-conductor used in the sensitive element of a thermistor, the instrument has a very quick response. The element can be produced in a variety of designs for special applications, including probes which can be lowered into the bulk of liquid in a container. By suitable choice of the semiconductor, linearity of response over a wide range of temperature can be obtained. The thermistor is used in conjunction with an electronic bridge circuit, and an indication is provided by a potentiometer. To increase the range the instrument can incorporate an amplifier and stepping switch. Some zero-drift is experienced with thermistors, and an error can arise from auto-heating of the semiconductor. Zero adjusting facilities are, therefore, incorporated in the indicating instrument, and the indication shall be checked, and, if necessary, reset, at each end of the scale before and after taking a series of readings. The sensitive element shall not be energized for long periods, the indicating instrument being switched on only for a sufficient time to enable the reading to be taken. A spring-loaded pushbutton switch returning to the off-position shall therefore be fitted. The indicator used shall conform generally to the specification given in **4.8.4.1** or **4.8.4.2**.

4.8.4 *Indicators*

4.8.4.1 *Permanently mounted instruments* — Any commercially available indicators suitable for use with resistance thermometers as described in **4.8.1** or thermoelectric pyrometers as described in **4.8.2** and which conform to the following specification may be employed for permanently installed equipment:

a) *Range* — The instrument may be of any convenient range to cover the minimum and maximum operating temperature expected. Instruments provided with a dual scale covering two ranges and a range-change switch can also be used. Convenient ranges for such instruments are 0° to 40°C and 30° to 70°C.

b) *Scale Length* — The length of scale shall be such that the distance between adjacent scale marks shall not be less than 2·5 mm.

c) *Scale Division* — 0·5°C.

d) *Index* — A knife-edge pointer, preferably together with a mirror band on the scale, shall provide discrimination to within 0·25°C.

e) *Accuracy* — The error at any point on the scale for the complete equipment when used within an ambient range of —10° to +50°C shall not be more than

±0·25°C for resistance thermometers, and

±0·5°C for thermoelectric thermometers.

4.8.4.2 *Portable instruments* — The alternative portable type of indicator recommended for use with a resistance element or thermistor shall be provided with a protecting lid and shall be self-contained with all accessories. The scales shall be engraved with two ranges, 0° to 40°C and 30° to 70°C, both scales subdivided in units of 0·5°C. The galvanometer shall be magnetically shielded and of approved shockproof pattern, with an intrinsically safe measuring circuit. The instrument shall be complete with a dry cell, a battery standardizing rheostat, and range-change switch and shall conform in other respects with the specification for permanently mounted instruments.

Three-core copper cable of minimum length 2 m and having oil resistant insulation and sheathing, preferably overcovered with rustless flexible metallic tubing, shall be provided with portable indicators for resistance thermometers. One end of the cable shall be securely attached to the indicator case, and the other end provided with a three-pin plug to fit the sockets on the thermometer assembly. The plug shall be so designed that on insertion or removal from the socket the battery circuit shall first be de-energized before the thermometer circuit is made or broken. The cable for thermistor thermometers shall be synthetic rubber insulated and shall be resistant to immersion in petroleum products. The cable shall be long enough to cover the full depth of the tank.

4.8.5 *Maintenance* — Resistance and thermoelectric pyrometers shall be checked twice a year with a standard thermometer; the indicating or recording device shall receive adequate and regular maintenance.

4.8.6 The thermometric apparatus (excepting resistance thermometers) employed are usually permanently installed with the actuating bulbs fitting closely in the thermowells. Sensitive elements of resistance thermometers and actuating bulbs of other instruments shall be kept in good thermal contact with the thermowells by means of a film of thin oil, say kerosene or gas oil. In case of thermoelectric pyrometers no oil film is necessary since only a point contact is required.

4.9 Armoured Cases for Thermometers — Wherever required, the armoured cases for thermometers as described in **3.3.2** of IS : 1519 (Part 1)-1983* shall be used.

5. PROCEDURE

5.0 For casing-head, aviation or motor gasoline or crude oil in pressure storage, thermowells in conjunction with suitable thermometers may be used in accordance with requirements given in **4.1** to **4.4**. But when the tank is fitted with a gas-lock (*see* **4.5**), temperature determinations may alternatively be made using a special sampler (*see* **4.5.3**), illustrated in Fig. 1. This equipment has the advantage over thermowells in that the temperature readings can be obtained from any desired level, but in view of its construction it is often difficult to operate, and reliable readings are not readily obtained in poor light or under bad atmospheric conditions. On this score, thermowells may prove preferable. *In no circumstances shall the gas-lock be used on tanks where high pressure makes its use hazardous.* The high pressure limit is generally governed by the safety considerations applying to any particular installation employing this device.

5.1 High-Pressure Tanks

5.1.1 *With Thermometers in Thermowells* — Bulk quantity calculations for LPG, stored at ambient temperatures in pressure tankage require measurements to be made on the vapour phase in addition to the normal measurements made on the liquid phase. The vapour-phase measurements are necessary for the determination of the liquid equivalent of the vapour, which if ignored can result in errors of more than 5 percent of the total quantity of LPG contained in the tank. Accordingly, all thermometers fitted to the tank shall be read and the individual readings shall be recorded to the nearest 0·5°C. The average of the readings obtained on all the thermometers situated in the tank shall then be taken as the 'mean vapour-space temperature'. The average of the readings obtained on all thermometers situated below the liquid level less than 15 cm below the liquid surface shall be taken as the 'mean temperature of the liquid'.

Note — The pressure in the vapour phase shall be read and recorded to the nearest 0·1 kgf/cm^2.

5.2 Low-Pressure Tanks

5.2.1 *With Thermometers in Thermowells* — The procedure as described in **5.1.1** shall be followed, except that the measurements in the vapour space are not required.

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*Method for temperature measurement of petroleum and its products, Part 1 (*first revision*).

5.2.2 *With Gas-Lock-Method of Using for All Types of Tank* — The valve between the gas-lock and the tank shall be closed, the vapour-tight glass-window door opened and the sampler attached to the winding-gear, care being taken that the thermometer is in such a position that it can be read through the glass window, that the latter is clean and the sampler open. The gas-lock door shall then be closed and fastened, the valve opened and the sampler lowered to the required level in the tank contents (*see* **5.3** and **5.4**). The sampler shall be flushed for at least two minutes by repeatedly raising and lowering through a distance of approximately 0·5 metres. It shall then be closed and rapidly drawn up to the window, when the temperature shall be read to the nearest 0·25°C and recorded immediately. Care shall be taken to avoid parallax errors. The sampler shall then be emptied by operating the winding gear. When, however, the equipment is fitted with a single and not a double winding-gear, the sampler shall be withdrawn from the lock for emptying. To do this the tank valve shall be closed, the pressure shall be released from the lock by the pet-cock and the door may then be opened to remove the sampler for emptying and resetting. Although giving equally reliable temperatures, these arrangements of the gas-lock apparatus are not recommended for operational reasons in view of the long time required. The process shall be repeated for the remaining samples required (*see* **5.3** and **5.4**) and when the last sample has been drawn the valve shall be shut and the gas-lock closed.

NOTE — Great care shall be taken to see that the winding-gear and the pressure door on the side of the gas-lock are securely fastened before the gate-valve to the tank is opened. In any case this valve shall be opened slowly. Precautions shall be taken to ensure that before opening the gas-lock door, the gate-valve is shut and that all pressure in the lock has been released to atmosphere by the pet-cock provided.

5.3 Vertical Tanks

5.3.1 In vertical tanks fitted with a gas-lock and containing casing-head, aviation or motor gasoline, when the oil depth is greater than 3·5 m, upper, middle and lower samples shall normally be drawn at levels equivalent to one-sixth, one-half and five-sixths of the total oil depth. If the temperature of the middle sample does not differ from the average temperature of the three samples by more than 0·5°C, this average temperature shall be taken as the temperature of the tank contents. If this is not so, additional samples shall be drawn at one-tenth, three-tenths, seven-tenths and nine-tenths of the oil depth. If the average temperature of these four samples and the middle sample does not differ from the average temperature of the previous upper, middle and lower samples by more than 0·5°C, then the average of all temperatures shall be taken as the mean temperature of the tank contents. If the difference is still greater than 0·5°C, the process of taking additional samples and determining new average temperatures shall be repeated, although such a procedure will very seldom be required. Samples shall not, however, be drawn from levels less than 15 cm below the oil surface or less than 15 cm above the bottom of the oil layer.

5.3.2 When the oil depth is less than 3·5 m and greater than 2 m, two samples shall be drawn at levels equivalent to one-quarter and three-quarters of the oil depth. The average temperature of these two samples shall be taken as the temperature of the tank contents, when this average temperature does not differ from the temperature of either sample by more than 0·5°C. When a difference greater than 0·5°C is found a middle sample shall also be drawn, and the average temperature of the three samples shall be taken as the mean temperature of the tank contents.

5.3.3 When the oil depth is less than 2 m one sample only need be taken. This shall be at the centre ot the oil depth, and the temperature of this sample shall be regarded as the mean temperature of the tank contents.

5.3.4 In vertical tanks containing crude oil a procedure similar to that outlined in **5.3.1**, **5.3.2** and **5.3.3** shall be used, except that a tolerance of 1°C shall be permitted.

5.4 Horizontal and Inclined Cylindrical Tanks

5.4.1 In horizontal and inclined cylindrical tanks fitted with a gas-lock and containing casinghead, aviation or motor gasoline or crude oil, and which are full or nearly full, upper, middle and lower samples shall be drawn at levels equivalent to one-sixth, one-half and five-sixths of the oil depth. The temperature of these samples shall be read and recorded to the nearest 0·25°C. The mean temperature of the tank contents shall then be taken as one-tenth of the sum of three times the temperatures of the upper sample, four times the temperature of the middle samples, and three times the temperature of the lower sample, rounded off to the nearest 0·5°C.

5.4.2 The case of a partially-filled horizontal cylindrical vessel requires the attention of an experienced operator. In general, the levels chosen for sampling will be those corresponding to one-sixth, one-half and five-sixths of the total volume of oil contained in the tank at the time the temperatures are taken. These levels can, of course, be found only by reference to the tank capacity table. The temperature of each sample shall be read and recorded to the nearest 0·25°C and the average of the temperature so recorded, rounded off to the nearest of 0·5°C, shall be taken as the mean temperature of the tank contents. When, however, the oil depth is less than 2 m, only one sample need be taken. This shall be drawn from the level corresponding to half the oil volume. The temperature of this sample shall be read and recorded to the nearest 0·5°C and shall be regarded as the mean temperature of the tank contents.

5.4.3 It is the usual practice to insert one or more ordinary liquid-in-glass thermometers in gauge-glasses when these are fitted. Such thermometers are, however, used solely to ensure that the gauge-glass contents are at or near the temperature of the contents of the tank before gauge-glass readings are taken. This is accomplished by flushing the gauge-glass with the liquid in the tank prior to taking any temperature measurement. In no circumstance, shall the temperature indicated by these thermometer be used in determining the mean temperature of the tank contents.

5.5 Pressure Tanks for Rail Wagons, Tank Wagons and Road Vehicles

5.5.1 Temperature measurements in pressure rail cars and road vehicles are normally not required since their contents are usually weighed. If a temperature is required, it may be obtained with a liquid-in-glass thermometer in conjunction with the single vertical thermowell which is usually installed in the top cover. Pressure rail tank-wagons and bulk lorries are preferably fitted with a permanently installed indicating thermometer (*see* **4.8.4.1**), the sensitive portion of such thermometers being located at approximately the centre of the liquid contained in the tank when it is filled to its maximum working level. The thermometer should be of robust design capable of withstanding the shocks to which a mobile tank is normally subjected. The thermometer should be supplied complete with a pocket which shall be permanently installed in the tank and which shall be fully in accordance with the pressure requirements of the particular tank. Mercury-in-steel indicating thermometers are recommended or alternatively bimetallic fully compensated thermocouples may be employed. Alternatively, where only thermowells are provided to facilitate temperature measurement, the mercury-in-glass thermometers shall be used with armoured cases. The thermowell shall contain low viscosity oil, say kerosene or gas oil, in order to obtain good thermal contact between the well and the thermometer. Ample provision shall be made for viewing the scale.

5.5.2 The armoured thermometer shall be lowered in the well to a position corresponding to the centre of the oil depth and shall remain at the level for sufficient period to allow the thermometer assembly to attain the temperature of the oil. The thermometer shall then be raised and the temperature read and recorded immediately. The perforated end of the case shall be kept in the well whilst the thermometer is being read. The temperature so recorded, rounded off to the nearest 0·5°C, shall be taken as the temperature of the contents of the container.

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